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OPENER/ROTATION STUDY: THE EFFECT OF OPENER DISTURBANCE AND CROP ROTATION ON WEED POPULATIONS IN THE DRY BROWN SOIL

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Opener/Rotation Study: The Effect of Opener Disturbance and Crop Rotation on Weed Populations in the Dry Brown Soil

Summary:
The objective of this study is to evaluate the effect of soil and seedbed disturbance on weed populations and crop establishment in the Dry Brown Soil Zone. The study will also evaluate the agronomic performance of a diverse, extended rotation, with different levels of soil disturbance. After two years of this study, some trends are emerging. The very low disturbance angle disc has shown significant advantages in both wet and dry years. In all four years of this study, weed populations were significantly lower with angle disc opener than the other openers. There was also a trend of a yield advantage with the disc opener for most crops in all years. Although the angle disc had the highest yields and lowest weed populations, the knife has shown a trend starting in 2000 and continued into 2001, of less weed density and higher yields over the spoon and sweep. It appears that it takes some time for weed densities to lower when using a knife in the lighter textured soils. The overall trend was that the higher the level of soil disturbance, higher weed densities occurred and conversely, lower yields were also experienced with openers using higher levels of soil disturbance.

Background and Objectives:
Direct seeding is becoming more popular with farmers in the brown soil zone as more producers recognize the advantages of this farming system over conventional systems. Research has shown the benefits of a diverse rotation and low disturbance direct seeding in increased yields, seed protein content, soil organic matter, and erosion resistance. Research elsewhere has also indicated that there can be a reduction of certain annual weed populations, such as wild oats and wild millet. However, in the dry brown soils, particularly the light textured soils in this region, this reduction of weed populations has not been readily observed. Due to severe moisture limitations in the Dry Brown Soil Zone, the effect of weed pressure is magnified and will have a greater impact on yield than will occur in other soil zones. Weed control is critical for alternative crops such as oilseeds and pulses, especially in the early developmental stages. Since the margin for profit is much narrower for farmers in the dry brown soil zone due to lower potential yields, any advantage reducing the weed populations as a result of the opener will reduce input costs and make the option of including non-cereal crops more viable.

The objective of this study is to evaluate the effect of soil and seedbed disturbance on weed populations and crop establishment in the Dry Brown Soil Zone. The study will also evaluate the agronomic performance of a diverse, extended rotation, with different levels of soil disturbance.

Project Activities:
The site is located six miles southwest of Aneroid on a sandy loam soil. This completes year three of a four-year study. Four single shoot openers (angle disc, knife, spoon, and sweep) are being used in this study with increasing levels of soil disturbance, on four crops (durum, field peas, barley, and desi chickpeas) in a four-year, zero-till rotation. The four openers used in this study include an angle disc (Barton Generation I disc), 0.75-inch knife, 2.25-inch spoon and a 12-inch sweep. All openers are on 9-inch row spacings. Field scale equipment was used to seed this study (a 15-foot Flexi-Coil 5000 was used on the knife spoon and sweep, a 30-foot unit seeded with the Barton Disc). Plots are the width of the seeding implement (15 or 30 feet wide) and 100 feet long. The four crops (Kyle durum, Delta peas, Harrington barley, and Myles desi chickpeas) are seeded side by side with all four openers seeding each crop and the plots are replicated four times for statistical accuracy.

Due to cold conditions and the time of seeding, the glyphosate burnoff treatment was applied post-seeding (May 3), using 0.5 litre/ac rate of Roundup Transorb. Seeding conditions were very dry with dry soil to a depth of two inches before any moisture was encountered. Plots were seeded April 28 under 30^0 C temperatures. Weeds were generally quite small, with a noticeable difference in weed densities between the angel disc and the other openers. Significantly less weeds were present in the plots using the angle disc as compared to plots using other openers at time of seeding. Plots were seeded between 2-3 inches in depth. However, the chickpeas were seeded only 2-inches deep on reps 3 and 4. The depth was reset to 3-inches for reps 1 and 2. All crops were seeded at a speed of 3-4 mph. The crops were seeded at the following rates:

Myles desi chickpeas:	110 lbs/ac
Delta field peas:	160 lbs/ac
Kyle durum:	90 lbs/ac
Harrington Barley:	70 lbs/ac

On each plot, weed population counts, crop establishment counts and yields are taken. There is a burnoff treatment with glyphosate and a no burnoff treatment. A no pre-seed burnoff treatment will show any effect of weed germination based solely on the level of soil disturbance each opener generates and the burnoff treatment will show any benefits of this weed control practice on the various openers and crops. Weed counts and crop establishment counts are taken on both treatments, to provide an indication of weed populations and its effect on the crop, based on the amount of soil disturbance occurring in the seeding process. Both the pre-seed burnoff treatment and the non-burnoff treatment will have in-crop herbicides applied as required. Two weed counts are taken. The first weed count is conducted just prior to spraying and the second weed count is taken about five or six weeks after the in-crop spraying treatment. Therefore, there are 128 plots in total. The weed counts involve 20-half metre square counts per plot, in which the numbers of each weed species is recorded. Yields of each crop and treatment are taken with a plot harvester.

Herbicides used included a tank mix of Achieve and Buctril M on the cereals. Odyssey was used on the peas and only Poast Ultra was used on the chickpeas.

The plots were seeded April 28. Crop establishment counts were taken on June 7 and the first weed count took place May 30-June 7. In-crop spraying with herbicides occurred June 15-16.

The second weed count occurred July 17-20. A summer field tour was held at the site on July 16 with 20 farmers attending. Results of this study have been included in various extension meetings throughout the winter months.

Yield samples were harvested from the plots using the Wheatland plot harvester.

Results and Conclusions:
Pea yield samples were harvested on August 28. Yield samples from the durum and barley were harvested on September 11 and the chickpeas were harvested on September 26. Weed densities were the highest this season as compared to the other years in the study with Kochia, wild buckwheat and wild oats being the dominant weeds. Although weeds took a while to emerge due to the cold spring, once a few days of sun and heat occurred, large numbers of weeds germinated. Another factor that resulted in high kochia numbers was that at the time of the burnoff, the plants were very small (about 0.5 cm tall) and in the fuzzy ball stage. It is extremely difficult for herbicides to penetrate into the plant during this stage.

The dry spring conditions certainly affected the establishment of most crops in the study and especially in a couple plots. Essentially no barley emerged in the spoon and sweep plots in Rep 3. Although there was a good weed kill after the in-crop herbicide treatment, rain in mid to late July brought on a new flush of primarily kochia weeds. Since the crop was maturing, there was little canopy or water uptake to provide much competition to the weeds. As a result, considerable densities of kochia resulted and in combination with the drought, crop yields suffered.

The performance of the knife was much better this year in most crops with respect to weed densities and initial impressions of establishment and yield. This is a continuation of a trend observed last year. It is likely that that time is required for weed densities to lower with this opener and consequently yields increase with reduced weed pressure. The difference in time between the knife and angle disc in response to reducing weed populations is likely a result of the angle disc has so little soil disturbance. With the angle disc, there is an immediate response in fewer weeds germinating in response to soil disturbance. The knife, although it is a low disturbance opener, does cause much higher level of soil disturbance than the angle disc, but generally not enough disturbance to cause significant weed control as compared to the sweep. After a few years, the weed seed bank reduces as a result of this lower disturbance level. This results in a lower weed density, but it has taken a few years before this occurs with the knife.

Another trend observed was the increasing incidence of foxtail barley on the no burnoff plots. Within the no burnoff treatments, the angle disc had highest densities of foxtail barley. There was less occurrence of foxtail barley the higher the level of tillage used during the seeding operation. This trend was especially evident on Rep 4. Canada thistle started primarily in the no burnoff treatments within Rep 4 and have slowly spread somewhat into the burnoff treatments. The densities of Canada thistle have increased noticeably in 2001 and again with densities decreasing with increasing level of tillage.

Crop Establishment:
There was a total of 5.85 inches of rainfall from March to the end of August of 2001 (Table 1).

Table 1: Inches of precipitation during 2001 growing season, Aneroid.

2001	Inches of Precipitation
March	0.0
April	0.0
May 14	0.1
May 16	0.1
May 29	0.75
June 4	0.8
July 15	2.0
July 24	1.1
July 31	0.9
August 23	0.1

The timing of the rains in mid to late July accounted for the late flush of weeds, particularly kochia. Extremely little rain early on in the growing season also accounted for poor establishment in some cases and yields overall. For most crops, the crop establishments were fairly close between the angle disc and the knife with the spoon and sweep generally resulted in less crop establishment, especially on the barley (Table 2).

Table 2: 2001 crop establishment means (plants/$m^{2)}$.

	Burnoff Treatment				No Burnoff Treatment			
	Angle Disc	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	57.79	52.54	46.9	48.49	46.77	51.06	42.26	42.15
Peas	70.16	71.22	60.47	64.5	59.13	70.68	61.47	64.23
Barley	126.15	132.46	32.25	44.88	113.42	122.63	21.12	41.66
Durum	90.57	124.7	95.14	76.87	84.71	119.34	76.33	69.34

Over the four years of the study, the angle disc resulted in the highest level of crop establishment in all crops and in wet or dry years (Table 3). The angles disc also resulted in the greatest reduction of crop establishment when there was no burnoff with a glyphosate. Overall, although the burnoff benefited all crops and all openers, it is evident that the burnoff becomes more important with the less disturbance opener being used.

Table 3: 1998 to 2001 crop establishment means (plants/m^2).

	Burnoff Treatment				No Burnoff Treatment			
	Angle Disc	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	54.29	43.60	40.63	39.82	46.33	39.96	36.57	36.40
Peas	71.77	57.68	55.67	55.80	63.91	56.47	55.08	54.33
Barley	110.81	92.52	75.43	70.24	100.18	86.52	64.64	66.85
Durum	103.84	97.35	88.87	84.28	96.35	90.06	81.91	79.81

First Weed Count:
The first weed counts are taken just prior to the in-crop herbicide treatment and were conducted between May 30 and June 6 in 2001. Weed populations were the highest in 2001 of all years in this study. It is likely that the few millimeters of rainfall in May of 2001 was enough to initiate weed growth. Kochia was the dominant broadleaf weed, but wild buckwheat was also common, and wild oats the primary grassy weed. The trend for all crops was that the higher the level of soil disturbance, the higher the weed density (Table 4). In 2001, the burnoff treatment had a significant benefit in all crops and for all openers over the no burnoff treatments.

Crop rotation also had a major impact on weed densities. As noticed in other years, there was also a trend of lower weed densities on the cereal crop following the peas (note durum weed densities, Table 4). When comparing the grassy vs. broadleaf weeds, it was evident that broadleaf weed densities were significantly lower in the cereal crop on pea stubble than those in the other crops (data not shown). This is likely a result of the residual carry-over from the herbicide Odyssey applied to the pea crop the previous year. It is unclear if there was a negative response to the cereal yield as a result of the Odyssey carry over.

Table 4: 2001 first weed count means (weeds/m^2).

	Burnoff Treatment				No Burnoff Treatment			
	Angle Disc	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	122.0	160.3	178.2	215.6	167.8	208.1	197.2	207.9
Peas	190.3	217.6	264.5	366	379.8	260.7	238.3	451.7
Barley	122.5	107.9	277.8	281.0	175.9	159.2	251.5	353.0
Durum	112.2	123.4	141.5	162.4	165.8	158.5	184.1	195.2

The very high weed densities in peas for 2001 also increased the four-year weed density means (Table 5). The weed densities from 1998-2000 however, indicate that peas generally have good competition with weeds (Table 6). The very high weed densities in peas also had an effect on the second weed count densities and also affected the four-year means in that count as well Table 7).

Table 5: 1998 to 2001 first weed count means (weeds/m^2).

	Burnoff Treatment				No Burnoff Treatment			
	Angle Disc	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	59.64	92.63	101.09	99.26	87.55	108.28	102.40	105.55
Peas	68.58	92.83	103.88	125.10	134.90	110.48	102.75	150.85
Barley	53.94	80.81	123.56	116.74	78.08	99.15	124.78	147.23
Durum	65.13	112.33	112.60	120.68	83.45	130.55	128.83	132.40

Cereals that were seeded onto chickpea stubble also tended to have higher weed densities, largely a result of poor weed competitiveness and only grassy in-crop herbicides are available for chickpeas.

Over the four years of the study, there was a general trend of the higher the level of soil disturbance at the time of seeding, the higher the weed density was, particularly in the last two

years of the study. The means of this four-year study can be a little misleading in that it is too short-term to reflect and indicate the effects of using each opener. As an example, the four-year average (Table 5) doesn't indicate it, but the trend observed over the past two years indicated there was an increasing density of weeds associated with higher levels of soil disturbance at time of seeding which is also reflected at the time of the first weed count (Table 6). The short-term advantages of the sweep and the time required for the weed densities of the knife to become reduced mask what the trend was clearly showing over the past two years.

Table 6: 2000 to 2001 first weed count means (weeds/m^2).

	Burnoff Treatment			
	Angle Disc	Knife	Spoon	Sweep
Chickpeas	85.18	115.15	132.44	145.71
Peas	116.61	136.55	165.00	212.30
Barley	83.33	108.66	187.63	191.98
Durum	94.96	144.76	153.30	173.95

The study also indicated that the advantages of the sweep are more short-term and over the longer term, sweeps do not provide the weed control as many producers expect. Another trend was that the glyphosate burnoff was increasingly important with openers that had decreasing level of soil disturbance. In addition, over time, there were increasing densities of perennial weeds like foxtail barley and Canada thistle occurring in the no burnoff treatments, primarily with the angle disc treatments and to a lesser degree, the knife.

Second Weed Count:

The second weed count was undertaken about five or six weeks after the in-crop herbicide treatment to all the plots. These counts were conducted between July 17 and July 20 in 2001. The second weed count can indicate the level of control and the level of potential weed problems there will be encountered in the subsequent year.

Table 7: 2001 second weed count means (weeds/m^2).

	Burnoff Treatment				No Burnoff Treatment			
	Angle Disc	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	97.9	108.5	136.2	123.3	102.8	148.5	138.7	156.2
Peas	65.8	67.1	80.8	92.4	56.8	56.2	77.3	89.0
Barley	32.5	48.7	172.7	139.4	56.9	61.0	180.8	149.1
Durum	40.7	60.4	66.1	62.0	47.8	79.0	76.8	73.2

2001 produced considerably higher weed densities in the second weed count (Table 7) as compared to other years in the study. This was likely due to new flushes of weeds after rains and the in-crop herbicide treatments. A general trend was that the low disturbance openers of the angle disc and knife still produced significantly lower weed densities as compared to the other openers, with the angle disc producing the lowest weed densities of all the openers. Crop rotation has played a role in weed densities. Chickpeas have only grassy in-crop herbicides available and

are also the least competitive crop. Cereals on chickpea stubble tend to have higher weed densities as result. The trend of chickpeas having high weed densities was reinforced over the four years of the study (Table 8).

Another trend was that the peas consistently had lower weed densities. The trend was clearly observable in the pea plots in the second weed counts in 2001 (Table 7) and over the four years of the study (Table 8). The reduction of weed densities was primarily from low broadleaf weed numbers. This was likely a result of the residual effect of the herbicide Odyssey on broadleaf weeds.

The trend that the weed densities for the knife were reducing was also reinforced by the 2001 data from the second weed count. With the exception of durum, the knife had weed densities very close to the angle disc, with a large difference between these two openers and the spoon and sweep (Table 7).

Table 8: 1998 to 2001 second weed count means (weeds/m^2).

	Burnoff Treatment				No Burnoff Treatment			
	Angle Disc	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	37.9	65.7	63.5	58.0	42.4	74.9	65.7	65.7
Peas	21.0	28.4	35.2	39.6	24.1	26.8	36.1	39.2
Barley	18.7	31.4	69.2	55.0	30.5	41.0	76.8	63.1
Durum	28.9	55.5	52.9	59.8	33.5	58.9	59.2	66.4

Yields:

The severe drought of 2001 played a major role in the resulting poor yields of all crops (Table 9). There was however, a general trend of lower yields with higher disturbance openers. Yield differences between the higher disturbance openers and the two low disturbance openers was greatest in the barley and durum. There was less yield difference between the angle disc, knife and spoon with peas, but this may also be a result of the severe effect of the drought. Peas were affected the most by the drought in 2001. There was a significant difference in yields between the two low disturbance openers and the two high disturbance openers with barley and durum. As with other years of the study, the angle disc was most effected by not having a pre-emergent burnoff with glyphosate. Although not as severely affected as the angle disc, the knife also had significant reductions in yield on the no-burnoff treatments. It is evident that the less soil disturbance the opener produces, the more important the burnoff treatment is. However, even the high disturbance openers showed yield and weed density benefits from the glyphosate burnoffs.

Over the four years of this study, the very low disturbance angle disc consistently produced the highest yields in all crops (Table 10). The yields using the knife have become closer to those of the angle disc, but it took three years before this gap became closer. It appears that there is a delay in realizing the benefits of a knife whereas the response to using a low disturbance disc is immediate. This is likely due to the knife causing a certain amount of soil disturbance but not enough to reliably kill weeds. It takes a few years before the weed seed bank becomes reduced

Table 9: 2001 yield means (bu/ac).

	Burnoff Treatment				No Burnoff Treatment			
	Angle Disc	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	13.04	11.79	11.42	10.09	6.5	10.07	7.67	9.99
Peas	7.59	7.71	7.00	6.10	4.39	4.79	4.85	3.78
Barley	13.98	20.74	5.12	6.39	8.38	18.31	8.42	8.91
Durum	9.56	9	5.98	6.55	4.85	8.36	4.3	6.34

as a result of using this opener. As noted in the 2001 results, over the four years of the study, the glyphosate burnoff generally benefits all openers regardless of level of soil disturbance in most years. However, the lower the level of soil disturbance of the opener, the more important it is to include a glyphosate pre-emergent burnoff in the operation. Not all years showed a burnoff benefit for the high disturbance openers. A longer study would be more conclusive in this aspect of the study. Another trend that would require a longer study to confirm is that the advantages of the sweep tends to be rather short-term. The longer it is used, the higher the weed densities become in comparison to lower disturbance openers, and the yields are correspondingly lower. In addition, a longer study would also indicate how close to the angle disc the yields and weed densities could become.

Table 10: 1998 to 2001 yield means (bu/ac).

	Burnoff Treatment				No Burnoff Treatment			
	Angle Disc	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	22.43	20.47	18.92	17.42	18.71	18.56	16.41	17.34
Peas	35.82	31.49	31.46	31.59	31.48	29.85	32.04	30.20
Barley	30.59	28.02	24.26	24.82	27.08	26.57	26.08	24.48
Durum	21.40	19.91	17.53	18.37	17.75	17.01	16.94	16.71

As noted in Table 10, there has been yield advantages in favour of the very low disturbance disc opener as compared to the other opens and in particular, when compared to the spoon and sweep (Table 11). As with the average yields, the average difference in yields for each opener when

Table 11: Yield difference (bu/ac) between angle disc in burnoff treatment and other openers, 1998-2001. For example, the chickpeas using the knife averaged 1.96 bu/ac less than the angle disc.

	Burnoff Treatment			No Burnoff Treatment			
	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	1.96	3.52	5.01	3.72	3.87	6.02	5.09
Peas	4.33	4.36	4.23	4.34	5.97	3.78	5.62
Barley	2.57	6.33	5.77	3.51	4.02	4.51	6.11
Durum	1.50	3.88	3.04	3.65	4.39	4.46	4.69

compared to the yield from the angle disc under the burnoff treatment, show a very similar trend with the knife being close to the angle disc and significantly higher differences with the spoon

and sweep. Table 11 also shows that on average, there was an advantage to applying a burnoff with glyphosate, even with high disturbance openers.

If we attach a value to the yield differences, a more definite economic picture can be observed (Table 12). For comparison purposes, the average price per bushel for each crop used is as follows:

chickpeas	$7.80/bu
peas	$3.75/bu
malt barley	$3.25/bu
durum	$4.00/bu

Table 12: Value of yield difference between angle disc in burnoff treatment and other openers, 1998-2001 ($/ac).

	Burnoff Treatment			No Burnoff Treatment			
	Knife	Spoon	Sweep	Angle Disc	Knife	Spoon	Sweep
Chickpeas	15.29	27.46	39.08	29.02	30.19	46.96	39.70
Peas	16.24	16.35	15.86	16.28	22.39	14.18	21.08
Barley	8.35	20.57	18.75	11.41	13.07	14.66	19.86
Durum	6.00	15.52	12.16	14.60	17.56	17.84	18.76

Table 12 indicates the dollar value per acre of the various crops and openers. The table shows some significant differences in return based simply on the opener used. For example, the sweep returned an average of $39.08/acre less than the angle disc over the four years of the study. The two high disturbance openers consistently have a much less return than the angle disc or even the knife. Table 12 also shows the value of the burnoff treatment.

Conclusions:

Very low disturbance disc openers, such as was used in this study, have shown significant advantages in lower weed densities, crop establishments and yields in most years and in wet and dry years in the Dry Brown Soil Zone. These advantages occurred immediately with the angle disc opener. Although the knife opener eventually produced lower weed densities and higher yields than the spoon or sweep, these improvements didn't occur until the third year of the study. The advantages of the spoon and sweep tend to be relatively short-lived and consistently produced significantly higher weed densities and lower yields on all crops, especially in the last two years of the study. A longer study would have more accurately shown long-term potential of the knife in comparison to the much lower soil disturbance opener of the angle disc. A longer study would also more accurately reflect the effects of high disturbance openers like the sweep.

Overall, the angle disc or any similar very low disturbance disc opener has a tremendous potential for the Dry Brown, Brown and likely the drier parts of the Dark Brown Soil Zones. However, personal anecdotal experience using the angle disc indicated problems of consistent seed depth in very stony soil combined with very dry soil conditions. The knife also has shown to have very good potential in maximizing yields while initiating less weed growth as compared to high disturbance openers. However, unlike the angle disc, there is a lag time before this occurs and producers need to be aware of this lag when making opener choices. The high disturbance openers are often the first choice of producers who switch from conventional farming practices

and move into a single pass seeding system. The choice of the sweep is often based on the premise that they will obtain good weed control by using the sweep and there won't be any consequence to yield. However, as this study indicates, any advantage of the high disturbance opener is generally short-lived and after two years, experiences much higher weed densities and lower yields. In addition, under dry years, crop establishment is significantly reduced due to drying down of the seedbed.

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